Quantification of Open Source Research Publications in Biological Sciences for Biological Weapons Development Utility

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BACKGROUND:

The Defense Threat Reduction Agency (DTRA) was founded in 1998 to integrate and focus the capabilities of the Department of Defense (DoD) that address the weapons of mass destruction (WMD) threat. To assist the Agency in its primary mission, the Advanced Systems and Concepts Office (ASCO) develops and maintains an evolving analytical vision of necessary and sufficient capabilities to protect United States (U.S.) and Allied forces and citizens from WMD attack. ASCO is also charged by DoD and by the U.S. Government generally to identify gaps in these capabilities and initiate programs to fill them. It also provides support to the Threat Reduction Advisory Committee (TRAC), and its Panels, with timely, high quality research.

ASCO ANALYTICAL SUPPORT:

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

There is on-going concern, expressed both by the scientific and national security communities, about the publication of scientific information that can be exploited in the development of biological weapons. There is little disagreement that aggressors intent on developing biological weapons can benefit from information published in the biosciences literature, and no one disputes that free and open exchange of scientific information is vital to a dynamic biosciences infrastructure. Disagreement arises in determining what, if anything, to do about the publication of scientific information that is deemed to be particularly relevant to a bioweapons program, knowing that dissemination of the same information among legitimate researchers could be essential to scientific advances leading to effective modes of treatment and prevention.

The current study was conducted in order to accumulate preliminary semi-quantitative data on the actual occurrence of such information in the scientific literature. In so doing, the hope is to add an objective perspective to a debate that, so far, has been largely based on anecdotal information. The study involved the review and analysis of articles from three respected publications - *Scientific American*, *Science*, and *Molecular Microbiology* - over the course of six months. The articles were evaluated using a set of criteria to rate their potential relevance to biological warfare proliferators (regardless of their technical sophistication). A single issue of *Infection and Immunity* - a journal focused on pathogenic microorganisms and the immune response directed against them - was included in the survey as an additional point of reference.

A total of 43 journal issues and 738 articles were reviewed during the study; of these, 126 were judged to be at least minimally relevant to the development of bioweapons. About 90% of the 126 articles were assessed in the range of "minimally relevant" to "somewhat relevant," and the average overall relevance score for these 126 articles was 3.3 (on a scale from 1 to 10 reflecting increasing relevance). The 4 reports assessed as most relevant were graded 9. Common research subjects among the 126 reports included: the mechanism of action of virulence determinants, regulation of expression of virulence determinants, mechanisms of drug resistance in infectious microorganisms, and characterization of the molecular events associated with the immune response.

The results from the study reaffirmed that the biomedical literature contains significant amounts of information that could be exploited in the development of biological weapons. With little effort it was possible to identify research results that, with sufficient time and expertise, could be used to create new and more efficient biological weapons. However, the results also suggest that the large majority of that information is likely to be exploitable only by sophisticated biological warfare programs, typified by that of the Former Soviet Union. Even the results assessed as most relevant during the course of the study could not be applied without significant additional experimentation and resources. These same reports are also critically important in advancing our understanding of pathogenic microorganisms and developing effective medical countermeasures, benefits that clearly must be weighed against any potential risks associated with their publication.

2.0 INTRODUCTION

The anthrax attacks of 2001, occurring in the immediate wake of the terrorist assaults on the World Trade Center, dramatically reinforced the potential threat posed by the intentional release of deadly biological agents and underscored the vulnerability of U.S. populations to terrorist-inflicted biological attacks. An outcome from the intense media coverage of the anthrax investigations was a greater appreciation by the American public in general, but more specifically by U.S. lawmakers and the scientific community, that the bioscience research base, which forms the basis for advances in biomedical science and other related fields, can be misapplied in the development and employment of bioweapons. Laws have been enacted to restrict access to potentially dangerous pathogens that are well suited for use as bioweapons, but these laws are impediments to unauthorized access - not absolute barriers. Most of the agents can be obtained from natural sources or through methods that circumvent shipping and handling restrictions. Furthermore, modern molecular biology techniques and unlimited access to nucleic acid base sequence information for a host of human pathogens provide the basis for engineering new pathogens with enhanced virulence.

It is this reservoir of bioscience research reports which has become the subject of attention among those who emphasize that publication of selected scientific reports could be highly relevant to bioweapons development efforts, as well as those who stress that unrestricted publication of these experimental studies are essential to continued advances in biomedical science which will ultimately lead to effective defenses against bioweapons. Recently published papers describing the engineering of a mouse poxvirus with enhanced virulence (1) and the recovery of infectious poliovirus from cells infected with synthetic virions (2) are often cited as examples of research that are particularly relevant to bioweapons development and should be considered for restrictions in the publication process. However, a consensus does not exist on what exactly constitutes "sensitive" research and what kinds of restrictions should be imposed. Indeed, during a recent workshop convened by the National Academy of Sciences to explore the issue of scientific publishing and national security, editors of respected scientific journals posited that the two papers identified above did not cross the unstated threshold that defines sensitive research (3).

Subsequent to that workshop, editors of several major publishing organizations issued a consensus statement acknowledging the need to protect the integrity of the scientific process by publishing manuscripts in sufficient detail to enable reproducibility, but also recognizing that on rare occasions it may be necessary to modify or refrain from publishing a paper whose potential harm could outweigh potential societal benefits (4). In the absence of generally accepted criteria to define research results whose publication should be restricted, publishers are left to their own editorial procedures for making that determination. While these processes may be more than adequate, they are not transparent and may not be helpful to investigators in designing and reporting their research.

The challenges of preserving a vital and dynamic scientific infrastructure, while discouraging the misuse of research results in the development of bioweapons, are complex; it is beyond the scope of this study to explore them. For in-depth treatments of the subject, we refer readers to recent reports from the Institute for Defense Analysis (5), the Monterey Institute of International Studies (6), and the Johns Hopkins Center for Civilian Biodefense Strategies (7). The purpose of this study was to obtain a semi-quantitative estimate of the number of publications, appearing in a designated set of respected biomedical research journals, that could be useful in the development of bioweapons - either by unskilled terrorists or in a sophisticated biological warfare program.

3.0 STUDY DESIGN

As an initial effort to gauge the scope of the issue, we reviewed the articles published in three journals over the course of six months; rating each research article against a set of criteria designed to characterize the relevance of the article to the development of a biological warfare capability - regardless of whether that program was sophisticated or rudimentary.

3.1 Journal Selection

The three journals selected for review included *Scientific American*, *Science Magazine*, and *Molecular Microbiology*. These journals were chosen because they represent different publishing formats, have different subject focuses, and have different, but overlapping, readerships.

Scientific American is one of the best known of a relatively few publications designed to provide accurate information on timely topics covering the full spectrum of scientific and technical disciplines. The articles are essentially detailed overviews, but they are not designed to serve either as outlets for current research results or as comprehensive reviews of the relevant literature. Furthermore, although they often provide theoretical explanations of technical processes, they generally do not provide detailed "materials and methods" sections and would not typically provide "cookbook" solutions. *Scientific American* is geared toward the nonspecialist, and its readership is broad, including nonscientists as well as scientists. The magazine is published once a month. Other publications that fall loosely in the category include *The Scientist* and *New Scientist*.

Science Magazine, like *Scientific American*, covers a host of scientific disciplines, from astrophysics to paleobiology, but unlike *Scientific American*, the articles are original, peer-reviewed research reports. *Science* articles typically contain only abbreviated descriptions of specific procedures, but detailed materials and methods are available on-line to subscribers. The journal also includes supplemental articles which are technically less detailed than the research reports; nevertheless, the journal is primarily focused on a readership of trained scientists across the spectrum of disciplines. It is published once a week, and it occupies a relatively small niche - one of the few other similar cross-disciplinary publications is *Nature*.

Molecular Microbiology is a peer-reviewed journal geared toward specialists engaged in basic research on the molecular biology of microorganisms. Articles generally follow a traditional format, which includes a detailed materials and methods section. The journal is published twice a month (once in December) in Great Britain, but its authorship is international and includes a substantial proportion of U.S. investigators. A number of other journals with similar focus and format exist; these include the *Journal of Bacteriology*, *Journal of Molecular Biology*, and the *Journal of General Microbiology*.

Another subset of journals, which may represent the ultimate extrapolation in relevance to biological warfare, includes those publications that focus specifically on pathogenic

microorganisms and host responses to infection. It includes a number of journals such as the *Journal of Clinical Microbiology*, *Infection and Immunity*, and the *Journal of Medical Microbiology*. The original plan for this study did not include a representative of this group; however, in order to obtain preliminary data for comparative purposes, a single issue of *Infection and Immunity* was included in the review. The journal is published monthly, but a single issue can have over 75 articles.

3.2 Review Process

The relevance of individual articles in each of the journals was assessed and recorded using a score-sheet, which included five sliding-scale grades corresponding to different criteria that could impact the relevance of the article to a bioweapons development program, plus an overall numerical assessment of the relevance of that article to a bioweapons development effort (**Attachment 1**). The five assessment criteria included:

- **Education level:** The level of education or experience necessary to utilize the information contained in the publication. The scale ranged from 1 (corresponding to a high-school education) to 10 (corresponding to post-doctorate experience).
- **Lag period:** The estimated lag period necessary to implement the reported results in the form of a new or improved bioweapon. The scale ranged from 1 (reflecting immediate payoffs) to 10 (indicating a lag time greater than five years).
- **Equipment complexity:** The complexity of equipment and materials that would be required in order to apply the results described in the research report. The scale ranged from 1 (corresponding to simple household materials) to 10 (corresponding to highly sophisticated materials and equipment).
- **Developmental phase:** The phase of the weapons development cycle to which the research was most applicable. The scale ranged from 1 to 5, corresponding to agent acquisition, research and development, agent production, weaponization, and employment.
- **Agent type:** The type of biological agent employed in the research study and its potential as a biological weapon. A one-to-five scale, partially based on the CDC Select Agent list and categories within that list (**Attachment 2**), was used to reflect their assessed potential as bioweapons. Studies which didn't utilize a specific microbial agent did not receive a score for this criterion. From high potential to low potential, the categories included:
    - 5 - Category A agents on the CDC Select Agent list
    - 4 - Other than Category A agents on the CDC Select Agent list
    - 3 - Human pathogens not on the CDC Select Agent list
    - 2 - Pathogens of animals and plants that don't typically infect humans
    - 1 - Nonpathogenic agents

Overall relevance: A subjective assessment of overall relevance was based on a combination of the individually graded factors and any other features of the research report that were uniquely associated with the development of a bioweapon. It is important to note that specific numerical scores in individual grading criteria did not

necessarily correlate with assessed score for overall relevance. For example, a low score in education level (criterion 1) could contribute to a report that was rated highly relevant because it might enable a terrorist group with limited technical capabilities to fabricate an effective bioweapon. Similarly, a "1" in the developmental phase criterion (facilitating agent acquisition) could contribute to a report that was rated highly relevant because it might enable an aggressor to obtain an effective bioagent more easily.

Each report was evaluated by a PhD scientist with training in microbiology or a related field, knowledgeable of the bioweapons development cycle, and experienced in assessing state-sponsored and terrorist programs for developing biological weapons. Evaluations were performed using a three-phase approach. The table of contents for each journal issue under review was examined, and articles that clearly bore no relevance to bioweapons development (e.g. articles on astronomy or anthropology) were eliminated from consideration. In the second stage, abstracts of remaining articles were evaluated to eliminate additional nonrelevant articles, and the remaining articles that were judged to be relevant or still questionable were evaluated in the third stage using full text copies of each article. Individual reports, judged to be relevant, were evaluated using the score sheet described above. In addition, a summary report (**Attachment 3**) was completed for each journal issue reviewed.

4.0 RESULTS AND DISCUSSION

The relatively small sample size used in this study and the subjectivity necessarily associated with the assessment process are important factors in determining the level of confidence to place in the conclusions drawn from the results. Nevertheless, this study represents a systematic approach to acquiring evidence that bears on important questions of scientific openness and protection of national security that, to date, have been debated largely on the basis of anecdotal reports and incidents.

The evaluation period of the study covered six months - from November 2002 through April 2003 - and it focused primarily on three journals - *Scientific American*, *Science Magazine*, and *Molecular Microbiology* - selected because they represent different publication formats, have different subject focuses, and are targeted at different readerships. One issue of *Infection and Immunity* was included in the review as a representative of yet another journal category, which is particularly relevant to the agents employed in bioweapons. That single issue of *Infection and Immunity* represented less than 3% of all the journal issues and it contained about 10% of all the articles reviewed during the course of the study, but nearly half of the articles in this single issue were judged to be relevant to a bioweapons development effort, and they represented over 25% of all the articles scored as relevant during the entire study. For this reason, and because a review of other *Infection and Immunity* issues affirmed that this issue was representative, the results are included in the following summary.

A total of 43 journal issues and 738 articles were reviewed during the study (**Table 1**). Of these 738 articles, 574 described biological systems, or relevant nonbiological topics, and 126 were judged to be at least minimally relevant to the development of bioweapons. These 126 articles were subjected to a closer analysis using the score sheet designed to capture important descriptive information in support of an assessment of relevance.

Table 1: Journals Reviewed During the Study

Journal Title	Issues	Total Articles	Biological Articles	Articles Assessed to be Relevant (% of Total)
Scientific American	6	39	17	1 (3%)
Science Magazine	25	377	235	18 (5%)
Molecular Microbiology	11	246	246	72 (29%)
Infection and Immunity	1	76	76	35 (46%)
Total	43	738	574	126 (17%)

Some of the criteria employed in the score sheet (e.g. type of biological agent employed in the research and estimated lag time to application) were important determinants in assessing overall relevance, but others were primarily descriptive. Although these were important in characterizing the nature of the report, they did not necessarily translate to

an overall relevance assessment that was directly proportional to the numerical scores for those criteria. For example, research results that could be exploited only by post-doctorate level scientists using highly sophisticated equipment may have low relevance to poorly trained and equipped bioterrorists, but the same results could be highly relevant to a sophisticated, state-sponsored bioweapons program.

Table 2 summarizes the distribution of scores for the 126 articles that were evaluated in greater detail, and **Figure 1** is a graphic illustration of the overall relevance scores for the 126 reports. **Tables 3** through **6** provide a more detailed breakdown of the data by individual journals, and **Figure 2** depicts the average scores for each of the evaluation criteria by individual journal. A complete tabulation of scores for the 126 articles is provided in **Attachment 4**.

Table 2: Distribution of Scores for Relevant Articles from All Journals

Score	Education Level	Lag Time	Equipment Complexity	Developmental Phase	Agent Type	Overall Relevance
1	0	4	0	0	2	18
2	0	0	0	121	9	33
3	0	1	0	3	93	23
4	0	1	0	1	6	31
5	1	3	2	1	6	8
6	0	4	3			2
7	3	9	10			5
8	33	31	42			2
9	89	34	69			4
10	0	39	0			0
N	126	126	126	126	116*	126
Average Score (Std Dev)	8.7 (0.6)	8.4 (1.9)	8.4 (0.9)	Not Calculated	Not Calculated	3.3 (1.9)

* N for Agent Type: 10 studies did not employ a specific agent.

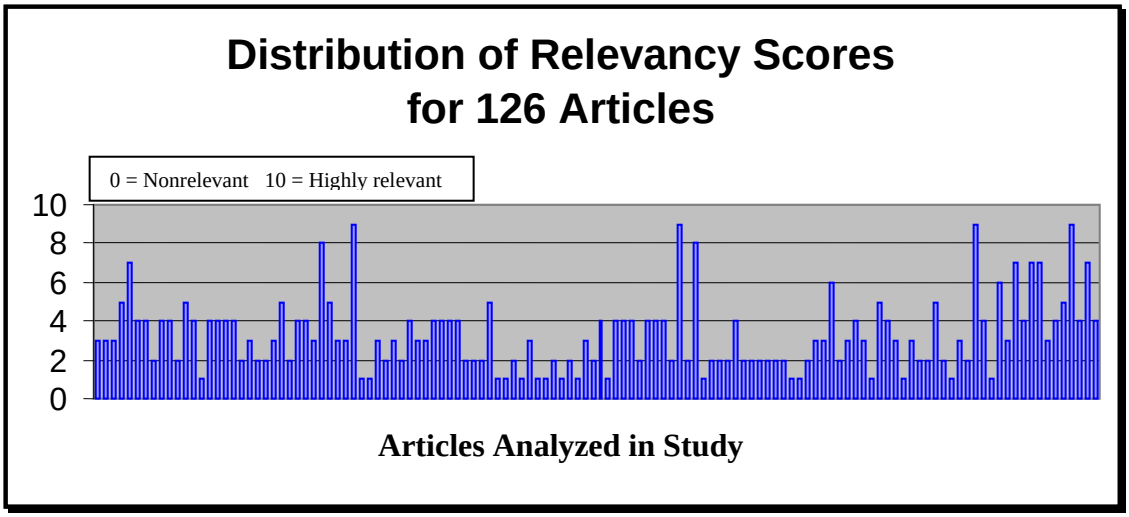

Figure 1: Distribution of Relevancy Scores

Table 3: Distribution of Scores for Relevant Articles from *Molecular Microbiology*

Score	Education Level	Lag Time	Equipment Complexity	Developmental Phase	Agent Type	Overall Relevance
1	0	0	0	0	2	11
2	0	0	0	72	5	16
3	0	1	0	0	59	14
4	0	1	0	0	1	23
5	0	1	0	0	2	5
6	0	3	3			0
7	2	5	4			1
8	21	22	27			1
9	49	15	38			1
10	0	24	0			0
N	72	72	72	72	69*	72
Average Score (Std Dev)	8.7 (0.5)	8.6 (1.5)	8.4 (0.8)	Not Calculated	Not Calculated	3.1 (1.6)

* N for Agent Type: 3 studies did not employ a specific agent.

Table 4: Distribution of Scores for Relevant Articles from *Science Magazine*

Score	Education Level	Lag Time	Equipment Complexity	Developmental Phase	Agent Type	Overall Relevance
1	0	2	0	0	0	3
2	0	0	0	16	2	12
3	0	0	0	0	9	0
4	0	0	0	1	0	1
5	1	0	2	1	1	0
6	0	0	0			0
7	0	0	3			0
8	5	1	1			1
9	12	6	12			1
10	0	9	0			0
N	18	18	18	18	12*	18
Average Score (Std Dev)	8.5 (1.0)	8.6 (2.8)	8.2 (1.4)	Not Calculated	Not Calculated	2.7 (2.2)

* N for Agent Type: 6 studies did not employ a specific agent.

Table 5: Distribution of Scores for Relevant Articles from *Scientific American*

Score	Education Level	Lag Time	Equipment Complexity	Developmental Phase	Agent Type	Overall Relevance
1	0	0	0	0	0	0
2	0	0	0	1	0	0
3	0	0	0	0	0	1
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0			0
7	1	0	0			0
8	0	1	0			0
9	0	0	1			0
10	0	0	0			0
N	1	1	1	1	0*	1
Average Score (Std Dev)	7.0 (NA)	8.0 (NA)	9.0 (NA)	Not Calculated	Not Calculated	3.0 (NA)

* N for Agent Type: 1 study did not employ a specific agent.

Table 6: Distribution of Scores for Relevant Articles from *Infection and Immunity*

Score	Education Level	Lag Time	Equipment Complexity	Developmental Phase	Agent Type	Overall Relevance
1	0	2	0	0	0	4
2	0	0	0	32	2	5
3	0	0	0	3	25	8
4	0	0	0	0	5	7
5	0	2	0	0	3	3
6	0	1	0			2
7	0	4	3			4
8	7	7	14			0
9	28	13	18			2
10	0	6	0			0
N	35	35	35	35	35	35
Average Score (Std (Dev)	8.8 (0.4)	8.0 (2.2)	8.4 (0.7)	Not Calculated	Not Calculated	4.0 (2.2)

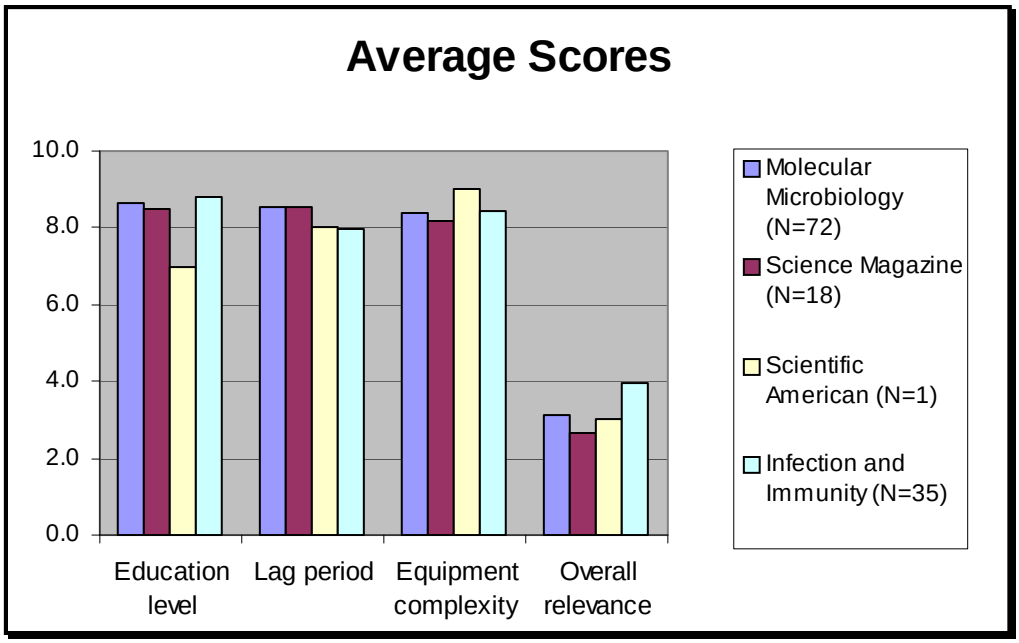

Figure 2: Average Scores

A substantial proportion (83%) of the articles reviewed during the study were assessed as not relevant to a bioweapons program; and of those that were judged to be relevant, most (about 90%) were in the range of "minimally relevant" to "somewhat relevant." Only 13 reports were graded in the top half (6-10) of the overall relevance scale. These numbers, in themselves, have only limited relevance to the question at hand, because individual reports, reporting highly significant results, can lead to important advances in a bioweapons program. Nevertheless, they do provide some sense of the scope of the issue.

The distribution of relevant articles between the four journals was consistent with the general publication focus of each journal - nearly 85% (107) of the relevant articles were published in the two journals that focused on microbiology. Both *Scientific American* and *Science* publish articles across the spectrum of biological and nonbiological disciplines and would be expected to have a lower proportion of relevant articles. Accordingly, during the six-month period, *Science* published 18 reports (5% of all articles) judged to be relevant to a bioweapons program, but the scoring profiles of these articles were similar to those of articles published in the microbiology journals. Only one report from *Scientific American* was judged to be relevant - a short technical note in the "Innovations" section describing a new approach to biodetection.

The research reports published in *Science*, *Molecular Microbiology*, and *Infection and Immunity* were generally similar. Most employed highly sophisticated techniques to explore the detailed molecular processes involved in infectious diseases. Common research subjects included: the mechanism of action of virulence determinants, regulation of expression of virulence determinants, mechanisms of drug resistance in infectious microorganisms, and characterization of the molecular events associated with the

immune response. The level of detail involved in these studies, the sophistication of the analytical tools employed, and the complexity of the biological systems being investigated were important factors that influenced how the reports were evaluated and contributed to higher numerical scores in the first three grading criteria - educational level, lag period, and equipment complexity.

Education level, Lag period, and Equipment complexity: Although it is easily conceivable that highly sophisticated research studies could lead to fundamental discoveries that are easily comprehensible to a nonspecialist and can be implemented quickly using nonsophisticated materials and equipment, such reports were not observed in this survey. And for all practical purposes, the assessed educational level, lag period, and equipment complexity necessary to implement reported results tracked closely with the technical complexity of the reported research. Accordingly, scores for these categories routinely fell in the 8 to 10 region - a result that is consistent with the technical sophistication of the journal articles that formed the basis of this study.

Developmental phase: All but 5 of the reports, evaluated during the course of the study, were judged to be most relevant to the research and development phase of the weapons development cycle - not an unexpected result, given the nature of the journals that were evaluated in the study. Among the few exceptions were articles describing a technique for purification of active botulinum toxin (agent production phase) (8), a technique for microencapsulation of biological agents (weaponization phase) (9), and a modeling study that analyzed the potential dissemination of smallpox in human populations (employment) (10). These reports were also among the reports that were scored highest on overall relevance. The scale consisted of discreet categories, which, though logically sequential, are discontinuous; and average values were, therefore, not calculated.

Agent type: The threat level of the biological agent employed in a reported study was viewed as an important determinant in assessing the overall relevance of that report. Like the developmental phase criterion, this scale consisted of discontinuous categories which were not consistent with the calculation of an arithmetic mean or standard deviation. However, an appreciation for the types of agents employed in the reviewed studies can be gained through a visual inspection of data in tables 2 through 6. Ten of the reports reviewed during the course of this study did not describe a specific microbial agent, and they were not given a score for this criterion.

Most of the agents employed in the reviewed reports fell into category 3 - human pathogens not on the CDC Select Agent list. It was a heterogeneous group that included opportunistic pathogens with virtually no BW potential (*Pseudomonas*), important human pathogens but unlikely choices as BW agents (*Mycobacterium tuberculosis*), and significant human pathogens that are spread by other than aerosol methods (*Salmonella* and *Shigella*). The list is assessed to be representative of organisms that, because of their clinical importance, are often the subject of research studies supported by the major U.S. funding agencies.

Of the 126 relevant reports, 6 involved the use of CDC category A agents (level 5), and most of these reports received high scores for overall relevance. The agents used in these studies included: B*acillus anthracis* (11, 12), *Yersinia pestis* (13), botulinum toxin (8, 14), and smallpox virus (10). Level 4 agents (other than category A agents on the CDC Select Agent list) were employed in an additional six studies, and they included *Burkholderia* (15), *Brucella* (16, 17, 18), *Rickettsia* (19), and *Coxiella* (20).

Overall relevance:

The average overall relevance score for the 126 articles that passed the initial screen was 3.3, and it was reasonably consistent for the three journals that had significant numbers of reports to evaluate. Of these 126 articles, 13 were scored 6 or higher, and 4 received the highest grade awarded of 9. These four articles dealt with the regulation of toxin synthesis in *B. anthracis* (11), a technique based on colloidosomes that could be employed for microencapsulation of microbial agents (9), purification techniques for activated botulinum toxin (8), and inhalational poisoning by botulinum toxin (14).

Although the results described in these reports are directly applicable to the development of a bioweapon, they are derived from basic research and would require significant additional research and testing before they could be implemented in the form of a bioweapon - they were not stand-alone "cookbooks." For example, the report on inhalational botulinum toxin involved the instillation of liquid preparations of the toxin into the nostrils of experimental animals - not the use of aerosolized material. For this reason, it is unlikely that a journal editor or publisher would argue that the material contained in these reports exceeds a hypothetical threshold and crosses into the realm of "sensitive" research that should be restricted in some form.

A better perspective for the relevance of these reports may be gained by comparing them with a selected research report, published in 2001, which exemplifies the concept of dual-use research with potential relevance for public health applications as well as bioweapons development. The report - "A powder formulation of measles vaccine for aerosol delivery" - describes a detailed technique for producing a respirable preparation of measles virus for use as an inhalation vaccine (21). The article identifies the equipment and operating parameters for milling lyophilized measles vaccine along with the procedures used to verify the resulting particle size and handling characteristics of the product. Although the techniques employed in characterizing the milled vaccine are relatively sophisticated, the instructions for preparing the material, itself, are relatively simple and are probably comprehensible to a minimally trained technician. The information could be implemented immediately, and though the technique would have to be adapted for the bioweapon agent of choice, it is likely that that could be accomplished with modest effort. Under the current climate of enhanced awareness of the potential danger in publishing dual use research results, this report could pose a significant dilemma. It describes a legitimate technique for preparing a vaccine of potentially great public health value, particularly in developing countries; but it also comes very close to being a virtual cookbook for weaponizing a biological agent. Using the score sheet from the current study, this report would have received the following approximate scores:

Education level - 3 (some college education); Lag time - 1 (immediate); Equipment complexity - 5 (somewhat specialized); Developmental phase - 4 (weapon development); Agent type - 3 (human pathogen); Overall relevance - 10 (highly relevant).

5.0 CONCLUSION

The small sampling conducted as part of this study provides an objective perspective into the issues that impact current concerns concerning scientific openness and national security. There is no doubt that the biomedical literature contains significant amounts of information that could be exploited in the development of biological weapons. With little effort it was possible to identify research results that, with sufficient time and expertise, could be used to create new and more efficient biological weapons. However, the results of this study also suggest that the large majority of that information is likely to be exploitable only by sophisticated biological warfare programs, typified by that of the Former Soviet Union. Even the reports assessed as most relevant during the course of the study could not be applied without significant additional experimentation and resources. These same reports are also critically important in advancing our understanding of pathogenic microorganisms and developing effective medical countermeasures. Nevertheless, the recent publication record clearly demonstrates that occasional reports with particularly important implications for bioweapons proliferation are and will continue to be published. These are the reports which should be and are the focus of the current concern over the misuse of the scientific literature.

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Attachment 1: Journal Article Review Form

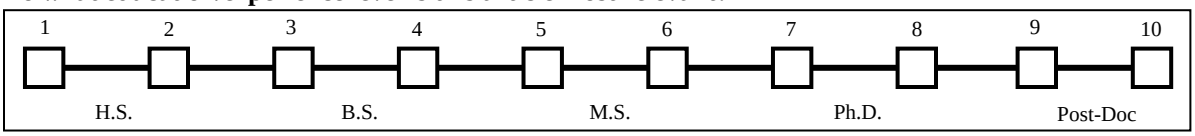
BIOSCIENCE LITERATURE REVIEW
Task Order 0007, Subparagraph 3.9,
Rapid Response Task No. RR 2-2

Journal Article Review

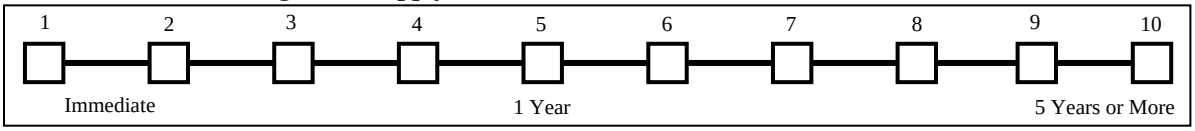
Journal citation:

Reviewer: _____ Date of review: _____

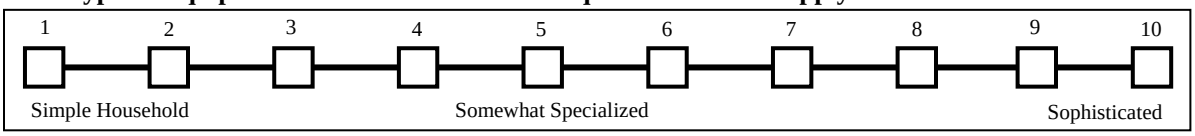
To what education/experience level is this article most relevant?



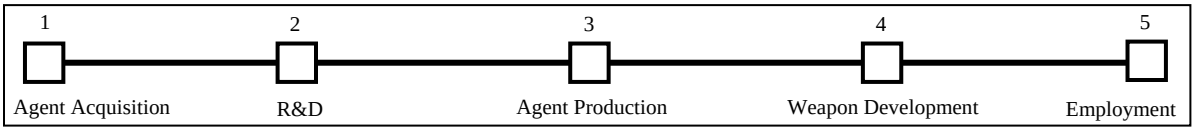
What is the estimated lag time to apply this information?



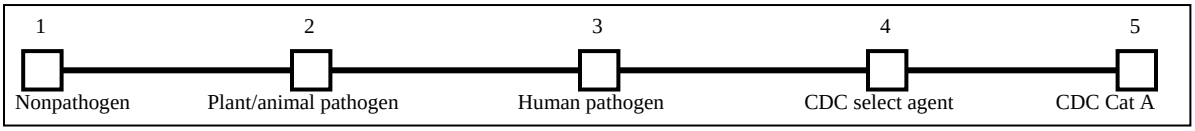
What types of equipment or materials would be required in order to apply this information?



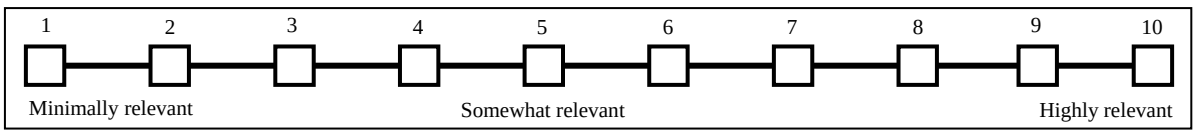
To what phase of the bioweapons development cycle would this information be most relevant?



What is the highest threat level of the organism described in the article?



What is the overall assessed relevance of this article to a bioweapons development effort?



Comments:

Attachment 2: CDC Select Agent List

CDC Select Agent List

Viruses:

1. Crimean-Congo haemorrhagic fever virus
2. Eastern Equine Encephalitis virus
3. Ebola viruses*
4. Equine Morbillivirus
5. Lassa fever virus*
6. Marburg virus*
7. Rift Valley fever virus
8. South American Haemorrhagic fever viruses* (Junin, Machupo, Sabia, Flexal, Guanarito)
9. Tick-borne encephalitis complex viruses
10. Variola major virus* (Smallpox virus)
11. Venezuelan Equine Encephalitis virus
12. Viruses causing hantavirus pulmonary syndrome
13. Yellow fever virus

Bacteria:

1. *Bacillus anthracis**
2. *Brucella abortus, B. melitensis, B. suis*
3. *Burkholderia (Pseudomonas) mallei*
4. *Burkholderia (Pseudomonas) pseudomallei*
5. *Clostridium botulinum**
6. *Francisella tularensis**
7. *Yersinia pestis**

Rickettsiae:

1. *Coxiella burnetii*
2. *Rickettsia prowazekii*
3. *Rickettsia ricketsii*

Fungi:

1. *Coccidioides immitis*

Toxins:

1. Abrin
2. Aflatoxins
3. Botulinum toxins
4. *Clostridium perfringens* epsilon toxin
5. Conotoxins
6. Diacetoxyscirpenol
7. Ricin
8. Saxitoxin
9. Shigatoxin
10. Staphylococcal enterotoxins
11. Tetrodotoxin
12. T-2 toxin

*** Denotes Category A agents**

Attachment 3: Journal Issue Review Form

BIOSCIENCE LITERATURE REVIEW
Task Order 0007, Subparagraph 3.9,
Rapid Response Task No. RR 2-2

Journal Issue Review

Journal name: _____

Date/Volume/Number: _____

Reviewer: _____

Date of Review: _____

Number of Articles Reviewed: _____

Number of Biological Articles: _____

Number of Relevant Articles[1]: _____

[1] For each article determined to be relevant, complete an individual score-sheet.

Attachment 4: Raw Scores for 126 Reports Judged to be Relevant to Bioweapons Development

Index #	Journal	Education level	Lag period	Equipment complexity	Developmental phase	Agent type	Overall relevance
1	Molecular Microbiology	9	9	9	2	2	3
2	Molecular Microbiology	9	8	8	2	3	3
3	Molecular Microbiology	9	8	9	2	3	3
4	Molecular Microbiology	9	3	8	2	3	5
5	Molecular Microbiology	9	6	8	2	4	7
6	Molecular Microbiology	9	8	9	2	3	4
7	Molecular Microbiology	9	8	9	2	3	4
8	Molecular Microbiology	8	10	8	2	2	2
9	Molecular Microbiology	7	5	6	2	3	4
10	Molecular Microbiology	9	8	9	2	3	4
11	Molecular Microbiology	9	9	9	2	2	2
12	Molecular Microbiology	9	7	9	2	3	5
13	Molecular Microbiology	9	8	9	2	3	4
14	Molecular Microbiology	8	10	8	2	1	1
15	Molecular Microbiology	8	8	9	2	3	4
16	Molecular Microbiology	9	8	9	2	3	4
17	Molecular Microbiology	9	8	9	2	3	4
18	Molecular Microbiology	9	8	9	2	3	4
19	Molecular Microbiology	9	9	9	2	3	2
20	Molecular Microbiology	9	9	9	2	3	3
21	Molecular Microbiology	9	10	9	2	3	2
22	Molecular Microbiology	8	10	7	2	3	2
23	Molecular Microbiology	9	9	8	2	3	3
24	Molecular Microbiology	8	7	7	2	3	5
25	Molecular Microbiology	9	10	9	2	3	2
26	Molecular Microbiology	9	9	8	2	3	4
27	Molecular Microbiology	9	8	8	2	3	4
28	Molecular Microbiology	8	9	9	2	3	3
29	Molecular Microbiology	8	6	9	2	5	8
30	Molecular Microbiology	8	7	8	2	3	5
31	Molecular Microbiology	9	9	9	2	0	3
32	Molecular Microbiology	9	9	9	2	0	3
33	Molecular Microbiology	9	4	8	2	5	9
34	Molecular Microbiology	9	10	9	2	3	1
35	Molecular Microbiology	8	10	8	2	3	1
36	Molecular Microbiology	9	9	8	2	3	3
37	Molecular Microbiology	9	10	9	2	3	2
38	Molecular Microbiology	9	9	9	2	3	3
39	Molecular Microbiology	9	10	8	2	3	2
40	Molecular Microbiology	7	6	6	2	0	4
41	Molecular Microbiology	8	9	6	2	1	3
42	Molecular Microbiology	8	9	8	2	3	3
43	Molecular Microbiology	9	7	9	2	3	4
44	Molecular Microbiology	9	8	9	2	3	4
45	Molecular Microbiology	9	8	8	2	3	4
46	Molecular Microbiology	8	8	8	2	3	4
47	Molecular Microbiology	8	10	8	2	3	2

48	Molecular Microbiology	8	10	8	2	3	2
49	Molecular Microbiology	8	10	8	2	3	2
50	Molecular Microbiology	9	7	9	2	3	5
51	Molecular Microbiology	9	10	7	2	3	1
52	Molecular Microbiology	9	10	9	2	3	1
53	Molecular Microbiology	9	9	9	2	3	2
54	Molecular Microbiology	8	10	7	2	2	1
55	Molecular Microbiology	9	8	9	2	3	3
56	Molecular Microbiology	9	10	8	2	3	1
57	Molecular Microbiology	8	10	8	2	3	1
58	Molecular Microbiology	8	10	8	2	3	2
59	Molecular Microbiology	8	10	8	2	3	1
60	Molecular Microbiology	8	10	8	2	3	2
61	Molecular Microbiology	9	10	9	2	3	1
62	Molecular Microbiology	9	9	9	2	2	3
63	Molecular Microbiology	9	10	9	2	3	2
64	Molecular Microbiology	9	8	8	2	3	4
65	Molecular Microbiology	8	10	8	2	3	1
66	Molecular Microbiology	9	8	9	2	3	4
67	Molecular Microbiology	9	8	9	2	3	4
68	Molecular Microbiology	9	8	9	2	3	4
69	Molecular Microbiology	9	10	9	2	3	2
70	Molecular Microbiology	9	8	8	2	3	4
71	Molecular Microbiology	9	8	9	2	3	4
72	Molecular Microbiology	9	8	9	2	3	4
73	Science Magazine	9	10	9	2	3	2
74	Science Magazine	8	1	5	4	0	9
75	Science Magazine	9	10	9	2	0	2
76	Science Magazine	5	1	5	5	5	8
77	Science Magazine	9	10	9	2	3	1
78	Science Magazine	9	9	9	2	3	2
79	Science Magazine	9	9	9	2	3	2
80	Science Magazine	9	9	9	2	3	2
81	Science Magazine	8	8	7	2	0	4
82	Science Magazine	9	9	9	2	0	2
83	Science Magazine	8	10	8	2	3	2
84	Science Magazine	9	10	9	2	3	2
85	Science Magazine	9	9	9	2	0	2
86	Science Magazine	9	10	9	2	0	2
87	Science Magazine	9	10	9	2	2	2
88	Science Magazine	9	10	9	2	3	1
89	Science Magazine	8	10	7	2	2	1
90	Science Magazine	8	9	7	2	3	2
91	Scientific American	7	8	9	2	0	3
92	Infection & Immunity	8	9	8	2	3	3
93	Infection & Immunity	8	7	8	2	4	6
94	Infection & Immunity	9	9	9	2	3	2
95	Infection & Immunity	9	9	9	2	3	3
96	Infection & Immunity	9	8	8	2	3	4
97	Infection & Immunity	9	9	9	3	3	3

98	Infection & Immunity	9	10	9	2	3	1
99	Infection & Immunity	9	8	9	2	3	5
100	Infection & Immunity	9	10	8	2	3	4
101	Infection & Immunity	8	9	8	3	3	3
102	Infection & Immunity	9	10	9	2	2	1
103	Infection & Immunity	9	8	9	2	3	3
104	Infection & Immunity	9	10	8	2	3	2
105	Infection & Immunity	9	9	8	2	3	2
106	Infection & Immunity	9	7	9	2	3	5
107	Infection & Immunity	9	9	9	2	3	2
108	Infection & Immunity	8	10	8	2	3	1
109	Infection & Immunity	9	9	9	2	3	3
110	Infection & Immunity	9	9	9	2	3	2
111	Infection & Immunity	8	1	7	3	5	9
112	Infection & Immunity	9	8	8	2	3	4
113	Infection & Immunity	9	10	8	2	2	1
114	Infection & Immunity	9	7	9	2	4	6
115	Infection & Immunity	9	9	8	2	3	3
116	Infection & Immunity	9	5	8	2	4	7
117	Infection & Immunity	9	9	9	2	3	4
118	Infection & Immunity	9	6	9	2	4	7
119	Infection & Immunity	9	7	8	2	4	7
120	Infection & Immunity	8	9	7	2	3	3
121	Infection & Immunity	9	8	8	2	3	4
122	Infection & Immunity	9	8	9	2	3	5
123	Infection & Immunity	8	1	7	2	5	9
124	Infection & Immunity	9	8	9	2	3	4
125	Infection & Immunity	9	5	9	2	5	7
126	Infection & Immunity	9	9	9	2	3	4